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ABSTRACT

The Zimbabwe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the first 2 years of secondary school without the aid of qualified teachers and conventional laboratories. This teaching guide, designed to be read in conjunction with the related student guide, includes instructional strategies, lists of required materials, laboratory procedures, and other information for activities and experiments in a four-part unit in which students investigate: (1) the three states of matter (solids, liquids, and gases) and kinetic theory; (2) expansion and diffusion; (3) gaseous behavior; and (4) chemical reactions. Each section in this guide corresponds to a given section in the student study guide. (JN)

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July, 1981.

Zim - Sci

Zimbabwe Secondary School Science Project

GENERAL SCIENCE

STUDENTS : Please read this carefully. It will help you.

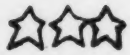
How you will study

This study guide comes to you with a kit of apparatus. Both things are part of a study programme leading you to an understanding of aspects of science. In this course you will be carrying out experiments. The study guide will help you to understand the scientific principles behind the experiments.

Your work should be done as you are instructed, either by the teacher or the study guide.

To help you to see quickly what you must do, the study guide uses these symbols.

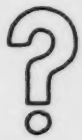
for "Read and revise your notes and Study Guide"



for "Take note of an important point that you should learn."

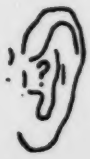
for "Summary". This is to help you to go over what you have learned.

for "Experiment".
When you see this sign, read the instructions carefully from beginning to end <u>before</u> you start to do the experiment.



for "How much do you know?"
This is for you, to help you to test whether you are remembering what is important.

for "Written work". This is when you must answer questions in writing.



for Listen to the teacher and do <u>exactly</u> what the teacher tells you to do

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UNIT C2 : PARTICLES IN ACTION

AIMS OF THIS UNIT

When pupils have completed this Unit they will be able to:

1. State the three states of matter - solid, liquid, gas.
2. Describe matter as being made up of very small, distinct particles which are in constant motion.
3. Identify motion of particles as being connected with temperature.
4. Deduce a model for the structure of matter based on experimental observation.
5. Explain changes in the state of matter by using the model.
6. Identify and explain in terms of the model the phenomena of thermal expansion, diffusion, variation in density and the relation between pressure and volume in a gas.
7. Define the molecule.

N.B.

SPECIAL NOTE

Please note that a new symbol has been included in this guide.

The symbol

denotes a 'danger' point. The usual danger will be either a fire hazard or the use of strong chemicals. Whenever you see this symbol, you should try out the experiment ahead of time to satisfy yourself about the danger involved.

Please note also that the meaning of the 'read' sign

has been altered slightly. It will be used in future to denote a revision lesson. You will find the use of this symbol is quite clear in the text.

PART 1

THE THREE STATES OF MATTER

This Unit is a continuation and extension of Unit C1. Pupils should revise Unit C1 thoroughly before beginning Unit C2. They should not begin Unit C2 until crystals have grown on the string, so that they can examine the crystals as instructed on Page 2 of the study guide for this Unit. Even if good crystals are not obtained by everyone, you should find that most people have a few large ones.

PAGE 2: Looking at the Crystals

You will need:

hand lenses (1 per pair)

The pupils can put all their good crystals onto a piece of filter paper, to dry them off before they study them. If they wish, they can continue to grow more crystals from their salt solutions: when they are tired of growing them they can give all the salt back to you. You can keep it for later use.

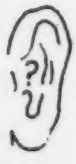
PAGE 4: EXPERIMENT 1: To make Crystals of Naphthalene

This experiment has a FIRE HAZARD. It would be a good idea if you tried the experiment yourself the day before the lesson, so that you can see for yourself where the danger lies.

If the pupils hold their boiling tins (with water) right over the top of the evaporating dish, as shown in the diagram then very little naphthalene vapour can escape. If there should be a fire, one quick puff of breath should put it out. The pupils should find beautiful flakes of naphthalene on the bottom of their boiling tin. Cleaning the boiling tin is important. When they heat the tin to clean it, very little naphthalene should be left on the outside.

If any of the pupils have lost their naphthalene, they could melt some more for themselves in their evaporating dishes. They do not need the foil. Give them 4 spatulas full of naphthalene, and tell them to heat it gently until it melts, then cool it again to see that it forms one big lump.

DISCUSSION OF NAPHTHALENE CRYSTALS



The pupils can look at their crystals with their handlens. The naphthalene crystals they have made are pure naphthalene. If the colour was different before, the naphthalene must have been IMPURE to start with. Perhaps they could even see other things (dirt, etc.) in their naphthalene before they heated it? Point out to them that this is one way of getting a pure substance - by heating, and collecting the vapour somewhere else. The impurities remain behind, in the evaporating dish. Also ask them why the naphthalene crystals formed on the bottom of the tin? What was the water inside the tin for? They can then answer Exercise 1.

Exercise 1

1. The shape of the naphthalene crystals was --------

2. The colour was ----------

3. If the colour was orange or black at first the naphthalene must have been ----------

4. The naphthalene crystallised on the boiling tin of water because ----------
---
---

5. The temperature of the tin must have been less than ----------°C.
(Think back to Unit A1!)

Answers for marking:

1. Flakes (flat on top and bottom).

2. White.

3. Impure (or similar idea).

4. The tin of water was cold, and the particles have to be quite cool before they can get close enough to form a solid.

5. Melting point of naphthalene: 78°C (or near this value).

PAGE 6: Solid Particles Moving

You will need:
scissors on the desk

The idea here is that you bang on the desk and the scissors jump in the air. This means that the banging energy you put in has been transferred across the desk by the particles of the desk itself, until the energy reaches the scissors. The scissors then move. Please try this beforehand to make sure that the scissors move. If your desk is a very heavy, solid one, you may not get good results. Perhaps you should then use a pupil's desk. Perhaps you can think of a better object to 'jump' than the scissors.

Ask the pupils whether they think that particles of a solid can move. You might like to read the following to your pupils:

"Look at my desk. Do you think the particles of the desk can move? They do not look as if they are moving! The desk is not running around the room! Perhaps they are only moving a little bit? But then the whole desk should move a little bit too? Do you think the particles could perhaps just move from side to side? Or up and down? Then they would not go from one place to another. How can we test this? Let us see if we can push them a bit. I shall hit the desk with my hand. What happens?

That's right, the scissors jumped up and down. Why did they do this? I did not touch them!"

The pupils should discuss this, and should eventually arrive at the idea that the particles of the desk 'banged into each other' all the way across, until they banged into the scissors and made them jump. After they have worked this out, return to the study guide.

PAGE 7: EXPERIMENT 2: Heating a Solid

Once again there is a FIRE HAZARD here. Please watch carefully to make sure that the pupils do not heat for too long. They should carry out the instructions exactly.

After this experiment the pupils can answer Exercise 2.

Exercise 2

1. The particles of a liquid can move:

   (a) less freely;

   (b) more freely - than those of a solid.

2. The particles of a liquid have:

   (a) more energy;

   (b) less energy - than those of a solid.

3. In Experiment 2, the particles got their extra energy from: ----------

   ----

Exercise 2: Answers (for marking):

1. (b)

2. (a)

3. The heat energy supplied by the burner.

PAGE 8: EXPERIMENT 3: Cooling Sodium Thiosulphate

You will need:

sodium thiosulphate - 4 spatulas per pair
handlens - 1 per pair

Please make sure that the liquid sodium thiosulphate is COMPLETELY COLD before the pupils add their 'seeding' crystal to start the process of crystallisation. They should feel the bottle getting quite hot as the crystals grow.

Exercise 3:

Write a report of this experiment.

Exercise 4:

1. Before the crystals were dropped in, the liquid was cold. When the large crystals grew, it became ----------.

2. This tells me that:

   (a) when a liquid changes to a solid it gives out heat energy; or

   (b) the liquid takes in heat to change into a solid?

3. If I wanted to change the solid back to liquid sodium thiosulphate again, I would have to ---------- the crystals.

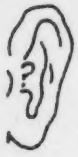
Exercise 4: Answers (for marking):

1. Hot
2. (a)
3. Heat

PAGE 10: EXPERIMENT 4: Heating a liquid

Once again there is a FIRE HAZARD. The danger is greater here that the naphthalene will catch fire. Please watch carefully and act quickly if anyone makes a fire.

GASEOUS PARTICLES



The pupils should guess that gaseous particles are quite free to move. They have more energy than the particles of a liquid so they move much faster.

PAGE 11: EXPERIMENT 5: Cooling Steam

Pupils should see steam condensing to water on their hand here, of course they should not hold their hand too close to the hot water!

Exercise 5

1. Particles of a gas have:
   (a) more energy; or
   (b) less energy - than particles of a liquid?
2. If a gas changes to a liquid, heat is
   (a) given out; or
   (b) taken in?
3. If I hold my hand in steam, I observe
   _____
   _____

Exercise 5: Answers (for marking):

1. (a)

2. (a)

3. Water forming on my hand because the gaseous steam changes back to liquid water. The steam gives out heat when this happens so my hand gets hot. (Or similar answer.)

PAGE 11: EXPERIMENT 6: Heating Wax

Each pair of pupils will need a small piece of wax for this experiment. You can cut up one candle to get pieces about this size, but not bigger than this:

BEWARE OF FIRE AGAIN HERE!

PAGE 12: EXPERIMENT 7: A burning candle

Each pair of pupils will need one short piece of candle. (Cut each candle into 8 small candles with wicks and give one to each pair.) Pupils should observe the flame jumping downwards from the match to the wick. They can repeat the experiment several times. Then they can answer Exercise 6.

Exercise 6:

1. When the solid wax changed to liquid wax I observed

   ---

2. When I put the match above the candle, I observed

   ---

3. This tells me that

Exercise 6: Answers (for marking):

The following answers are possible suggestions only:

1. The shape of the candle changing;
   the liquid forming one big drop;
   the liquid running freely.

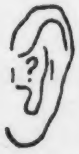
2. The flame 'jumping down' to the wick;
   the gaseous particles above the wick catching fire.

3. There are gaseous wax particles in the air above the candle. These formed when the liquid wax changed state and became a gas.

PAGE 13: SUMMARY: The Kinetic Theory

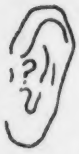
Please read this with the pupils and make sure they are happy with the ideas so far.

A MODEL OF PARTICLE MOVEMENT



The idea of this model is that the children themselves will pretend to be particles. They will first pretend to be in the solid state, then the liquid and lastly the gaseous state. They should observe closely while they are doing this. It will be easier if you take the class outside. You might like to read the following to your pupils:

"Remember the models you made before, in Unit C1? You used seeds to help you to understand how particles behave. Now we are going to make a model of the kinetic theory of matter - only we are not going to use seeds - we are to use ourselves! First study the diagram. Then come outside and I will tell you what to do.



All of you must arrange yourselves in rows of five, with arms linked together. (Any pupils remaining can join on at the back).

Stand exactly behind the person in front of you. The end people, who have a free arm, should put that hand on the shoulders of the one in front. Now we have a model of a solid. See how you can move from side to side. You cannot move very far!

Now everybody shake! You can see that the model gets a bit bigger, but not much.

Now, spread out until you are all just holding hands but keep moving around and shaking. You will see that you are not as close together as you were before. You are not as closely packed. Now you look like a liquid.

Lastly, break hands and run about freely. Now you are all gaseous particles! You are very far apart, and free to go wherever you like.

Let us do it again. Come back and link arms again as if you were solid particles. Now I want you to shake again- not yet! Wait till I say 'Go' - and I want you to look VERY closely at the model you are making. You will see that you have to get quite far apart before you need to join hands to become a liquid. The solid gets bigger. When you break to become a gas, the model gets MUCH bigger. Try this now and observe very well. Go!"

PAGE 14: PREPARATION FOR EXPERIMENT 10:

Each pair of pupils will need:

4 spatulas gelatin
water

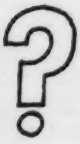
Pupils should put their names on their bottles. A good place to keep them would be in your cupboard. They should NOT be kept in a warm place.

REVISION

Please make sure that pupils revise Part 1 thoroughly. They should spend a whole lesson on revision. Then they can answer 'How much do you know?'

Answers (for marking):

1. Solid, liquid, gaseous
2. Liquid
3. Gas
4. Liquid, heat energy
5. Turns into a solid and gives out heat energy as it changes from one state to the other.
6. Gaseous
7. Solid



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PART 2

EXPANSION AND DIFFUSION

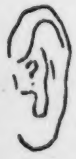
PAGE 16: EXPERIMENT 8: To show that Solids Expand on Heating

Each pair of pupils will need:

one straw
mounted needle

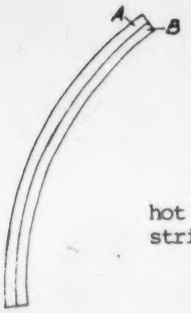
The position of the basic kit box is important. Please make sure that the edge of the pointer comes JUST in front of the box as shown in the diagram. Pupils should be able to see that the bar has expanded and particles have moved further apart. This movement causes the wooden bar to roll, thus moving the pointer.

PAGE 18: EXPERIMENT 9



The piece of apparatus to show the pupils is the BIMETALLIC STRIP. (Your bimetallic strip is a short piece of metal about 10cm long which looks like a piece of strip from a packing case.) As its name suggests, it is made of two different metals, joined together to make a strip. The idea is to see whether they expand by the same amount when they are heated, or whether different metals expand by different amounts. You will see from the diagrams how this works.

cold strip



hot strip

Strip of two metals A & B in equal lengths, fixed together all the way along their length.

This means A is longer than B, because A is on the outside of the curve, trying to remain next to a shorter length of B.

To demonstrate the Bimetallic Strip

You will need:

burner
Bimetallic Strip

Show the strip to the pupils and explain its structure. Then hold the strip with the peg and heat it in the burner flame. Make sure that you heat the whole length of the strip so that it can expand right along its length. Show the curved metal to the pupils and ask them what this means.

PAGE 19: EXPERIMENT 10: Spaces in a solid

Each pair of pupils will need:

a few crystals of copper sulphate
a few crystals of ammonium dichromate

After a short time, about an hour for the ammonium dichromate and several hours for the copper sulphate, the pupils should observe the coloured chemicals moving into the gelatin.

Exercise 7

Complete the report of this experiment. Then answer the following questions.

1. The gelatin, after cooling, was solid/liquid/gas?
2. I observed the coloured crystals ----------
3. This told me that ----------
4. In a solid, particle movement is slow/fast?

Answers to Exercise 7 (for marking):

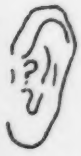
1. Solid
2. Diffusing into the gelatin (moving into the spaces in the gelatin)
3. There are spaces in a solid
4. Slow

Cleaning out the Gelatin from the Bottles

Bottles should be cleaned as soon as the experiment is completed, otherwise the gelatin begins to go rotten and smells! Most can be shaken out into the rubbish bin and the rest washed out with hot water.

Speeding up the Diffusion

The pupils should try to devise a method for speeding up solid diffusion. Do not tell them how to do it unless they cannot think of anything at all.



To do the experiment, they would have to make up new bottles of gelatin. The first idea might be to warm the gelatin so that the particles moved more quickly, then to put the crystals on top and observe the diffusion. Even gentle warming in hot water should help.

The next idea might be to dissolve the crystals in water and put the solution on top of the gelatin. This should also give quicker diffusion.

If any other good ideas are forthcoming, please allow pupils to try them out.

PAGE 20: EXPERIMENT 11: Does a Liquid expand when it is Heated?

This apparatus should be set up well before the lesson because the copper sulphate takes some time to dissolve.

You will need:

- burner and stand
- copper sulphate
- water
- spatula
- conical flask
- rubber stopper
- water
- thistle funnel (long glass tube with with a shaped top like this)
- small piece of paper, with a hole to fit the tube of the thistle funnel

First, slide the paper over the glass tube. Then put the tube of the thistle funnel into the hole on the stopper. If you find this difficult, rub a little GLYCEROL around the inside of the hole. Hold the glass tube close to the rubber stopper when trying to screw it in. Be very careful, it is easy to break the tube and cut yourself badly. The tube must not stick out on the underside of the stopper.

Then put 5 spatulas copper sulphate in the flask. Add water to about the 250ml mark and stir until the copper sulphate has dissolved. Then top up the flask with more water until it is completely full. Put the stopper into the flask firmly but not too tightly. When you push the stopper into the flask the copper sulphate solution will rise up the tube and there should be no air underneath the stopper. The apparatus will then look like the diagram in the study guide. If you push the stopper in too hard, it will rise up too far. Use your judgement here.

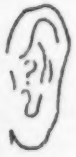
Use the sliding paper to mark the level of the solution in the tube. The apparatus is now ready for gentle heating. Show the pupils that heating the flask results in a rise of the liquid level in the tube. This indicates that liquids expand on heating.

PAGE 21: EXPERIMENT 12: To show that there are Spaces in a Liquid

You will need:

2 measuring cylinders
water
methylated spirits
stirrer

Put exactly 50ml water in the first cylinder and exactly 50ml methylated spirits in the second one. Ask the pupils to guess what volume will be obtained by mixing the two together. Then add the methylated spirits to the water. Stir well. Observe the new volume. You could pass the measuring cylinder around so that all the pupils can see it and then discuss the reason for the smaller volume. You should get about 96ml at the end instead of 100ml.



The reason for the decrease in volume is that some of the particles of methylated spirits can fit into the spaces between the water particles. This means that the volume is less than expected.

Exercise 8

Volume of water =

Volume of methylated spirits =

Expected total volume =

Actual total volume =

This is because ----------

HOW BLUE COPPER SULPHATE SPREADS THROUGH WATER

You may like to read this to the pupils:

"The small particles which make up copper sulphate and the small particles which make up water are all in rapid movement. They bump into each other all the time, and they move about using the spaces between the particles. After some time, the copper sulphate and the water particles are all mixed up together. Stirring helped the particles to mix by moving them around".

PAGE 22: EXPERIMENT 13: Diffusion in a Hot Liquid

Each pair of pupils will need:

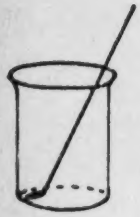
1 spatula copper sulphate (they could put this into their graduated beaker)
water

Please make sure that pupils do not stir either of their solutions. You could ask them why stirring would be a bad idea.

Exercise 9:

Write a brief report of Experiment 13.

Write: what you were trying to find out;
what you did;
what you observed;
what the experiment proved to you.



PAGE 23: EXPERIMENT 14: Heating a Gas

You will need:

water
1 balloon per pair of pupils
1 strip of paper per pair of pupils
starch (2 spatulas per pair)
drying cloth
thread

P

The strips of paper should be prepared ahead of time. They should measure about 1cm wide and about 50cm long. These measurements need not be exact. Two strips totalling 50cm between them will also be all right. Umtali paper is suitable for this experiment.

The starch is for making glue. Each pair of pupils can collect the starch in their evaporating dishes and make the glue. It should not stand too long or it will get dry. They should use it as soon as it is made.

Pupils should wind a piece of thread tightly around the neck of the balloon and tie it, or tie a knot in the neck. Make sure no air leaks out of the balloons. If thread is used it is easier to release the air and keep the balloon for re-use.

N. B.

The pupils should observe the balloon getting bigger and the ends of the strip moving apart. They should keep their boiling water for the next experiment.

PAGE 25: EXPERIMENT 15: Another look at a Gas Expanding

Each pair of pupils will need a 10ml syringe.

As the air expands, it comes out of the syringe.

Exercise 10

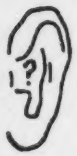
1. Balloon Experiment:

   Describe what you observed happening to the strip of paper and to the balloon.

2. Syringe Experiment:

   (a) what did you observe at the open end of the syringe?

   (b) why did the air come out of the syringe?



PAGE 26: EXPERIMENT 16: Diffusion of Iodine

You will need:

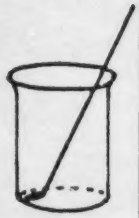
iodine crystals
conical flask and stopper
methylated spirits
burner and stand

Place two or three iodine crystals in the conical flask. Heat the flask gently as shown in the diagram until purple vapour starts to form above the crystals. The pupils should see that the vapour spreads quickly through the air in the flask, illustrating the idea of gaseous diffusion. Do not heat too long!

Note: we suggest you use a pupil burner for this demonstration as your burner is too strong!

When you have finished, take the flask OUTSIDE before you open it so that the purple iodine fumes can disperse in the open air.

PAGE 27: EXPERIMENT 17: Diffusion of Ammonia



You will need:

metre rule
clock
burner stand
evaporating dish
5ml measure
ammonia solution

Place the evaporating dish on the stand in the middle of the classroom (on the floor will be best). Note the time on the clock and put 20ml ammonia into the evaporating dish (using your 5ml measure 4 times).

NOTE THE WARNING ON THE AMMONIA BOTTLE ABOUT DANGER TO THE SKIN!

The pupils can measure the distance between them and the dish of ammonia, and can note the time taken for the ammonia smell to reach them. They can then estimate the speed of diffusion of the ammonia particles. Their measurement of distance need not be very accurate.

If the smell does not reach the back of the class, move up these pupils who cannot smell it until they are able to detect the smell clearly.

Exercise 11

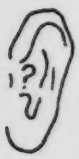
1. I smelt the ammonia at a distance of about --------m.
2. The time taken to travel this distance was ------sec.
3. Therefore the speed of diffusion was -------m/sec.
4. The ammonia smell was observed up to a maximum distance of about -------m.

Particle Model

This time the model is to be used to show diffusion. All the pupils should go outside once more. For this model, you should try to choose a place outside where there is some kind of wall. If there are two walls, as shown in the diagram in the study guide that would be even better.

Now you should mark the boundary of the space that the children will run around in. Mark it with stones or sticks - or even extra children.

Explain to the pupils that they are to form two groups. You could put all the girls in one group and the boys in another, or all in one group keep shoes on and the other group take them off - in fact anything will do that clearly divides one group from the other. Each group represents one kind of gaseous particle, and each group should start off in a bunch.



They should run around freely in the area you have marked out for them. They are pretending that they are gaseous particles and should be quite free. They may bump into each other sometimes, and they may bump into the walls. They will soon see for themselves that the two groups become mixed up very quickly. This is DIFFUSION.

Next the pupils should try to imagine that they are being squashed together. You might care to read the following text to them. While you are reading, you could move the stones inwards to make the space smaller and smaller. The pupils should NOT run more slowly, they should keep up the same activity as before.

"All of you should now imagine that the space in which you are moving is getting smaller and smaller. The walls around are coming in towards you. You have much less space to run around. What happens? That is right, you all get closer together. In fact you can be squashed up into quite a small space and still run about quite a lot. Your fast movement means that you are still pretending to be gaseous particles, but you have a smaller VOLUME OF SPACE in which to move. The walls have moved in and pressed you all together. Can you imagine that?

Now that you are all squashed up, you will see that you bump into each other more often. You also bump the walls more often. When a gas in a container is pressed into a smaller space, the gaseous particles bump the walls much more than they did before.

Return to your study guide now for a summary of the model."

PAGE 29: EXPERIMENT 18: Seeing the effect of Particle movement in Water

You will need:

- 2ℓ plastic bottle
- small bottle from basic kit
- spatula/stirrer
- methylated spirits
- naphthalene
- water

Put water into the large plastic bottle almost to the top. Into your small bottle put ½ spatula naphthalene. Fill the bottle with methylated spirits, put on the top and shake vigorously for some time. You will see that the naphthalene breaks up into small flakes and some of it then dissolves in the methylated spirits. When you feel that you have shaken for quite a time, allow the undissolved naphthalene to settle in the bottle. Then pour the methylated spirits into the water in the large plastic bottle.

The larger flakes of naphthalene will settle to the bottom

of the large bottle quite quickly. Wait for about five minutes to allow this to happen.

While you are waiting, discuss with the pupils what is happening to the pieces of naphthalene. You might like to read the following text:

"When the naphthalene was put into the methylated spirits, some of it dissolved. Naphthalene does not dissolve in water at all, but it does dissolve a little bit in methylated spirits. We had a situation where particles of methylated spirits and particles of naphthalene were in solution together. Then we poured the solution into water. The naphthalene does not like water very much so it started to come out of solution as tiny flakes. You have seen these flakes before, when you made naphthalene crystals.

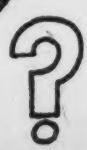
As the flakes come out of solution, they get bounced about by the rapidly moving water particles. You will be able to see them bouncing in a moment."

After explaining this, put the large bottle in strong sunlight. The pupils must look very carefully at the water and they will be able to see the shining of tiny flakes of naphthalene, like stars.

It may take a little time for them to adjust their eyes to see the flakes but they should observe them clearly after a while.

They might also observe that the pieces of naphthalene are drifting round and round the water in the bottle. This is because there are convection currents in the bottle. The Brownian movement is NOT this drift. Brownian movement is the tiny bouncing about in all directions of the naphthalene flakes. We see it as sparkling reflections of the sunlight off the shiny flakes.

Pupils should now spend a lesson on revision of Part 2.

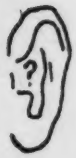


Answers to "How much do you know?"

1. Expand
2. Diffusion
3. Gases; liquids; solids

PART 3

GASEOUS BEHAVIOUR



Allow pupils to play with the bicycle pump. Point out to them that if they put their finger over the end of the pump, the pressure builds up inside the pump. When they remove their finger, the air comes rushing out. Ask them to explain to you (in Kinetic terms) what is happening to the particles of air.

PAGE 31: EXPERIMENT 19: What happens when some of a Gas is taken away?

You will need:

10ml syringe (one per pair of pupils)
water

Pupils should observe a decrease in the volume of air inside the syringe when they put it into cold water.

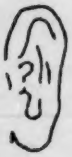
Exercise 12

1. First reading of syringe = ————ml.
2. I put the syringe in boiling water in order to
   ————————————————————————————
   ————————————————————————————
   ————————————————————————————
3. Second reading of syringe = ————ml.
4. Difference in readings = ————ml.
5. Therefore volume of air which must have escaped when the air was heated was ————ml.

Answers to Exercise 12 (for marking)

1. 10ml.
2. Allow the air to expand and escape.
3. (About 8ml.)
4. (2ml.) as obtained by pupils
5. (2ml.)

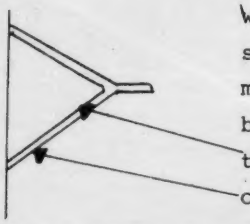
Rubber Suction Cups



Allow the class to stick the suction cups to many different surfaces. They will probably find that some surfaces stick better than others. The close fitting shape of the suction cups and the fact that there is now excess pressure on both sides makes two suckers stick very tightly together.

Exercise 13

1. When the rubber suction cup is pushed down there are:
   (a) more air particles in the space underneath the suction cup than before;
   (b) less air particles in the space underneath the suction cup than before.

2. 
Which side of the suction cup has the most air particles banging against it, the inside or the outside?

3. Which side has the greater PRESSURE of air particles?

4. Explain why the suction cup sticks to the surface.

Answers to Exercise 13 (for marking)

1. (b)
2. Outside
3. Outside
4. Excess pressure on outside pushes sucker against the surface.

PAGE 34: EXPERIMENT 20: The proper use of a Syringe

Each pair of pupils will need:

10ml syringe
water

Exercise 14

1. First reading of the volume of the syringe =
2. Second reading of the volume of the syringe =
3. The syringe filled up with ----------.
   This was because ----------

Answers to Exercise 14 (for marking)

1. 0ml.
2. 10ml.
3. Water - because the air was pushed out of the syringe and when the plunger was pulled back water came in to take its place.

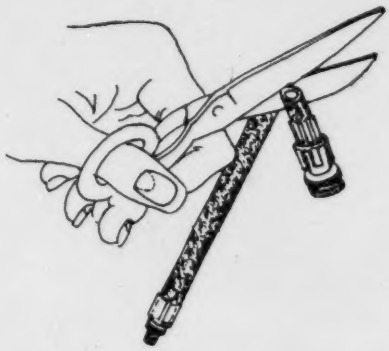
PAGE 34: EXPERIMENT 21: The Pressure Gauge

It is important that pupils realise that pressure is a physical property which can be measured like length, temperature, etc. This experiment is to construct a simple instrument for measuring pressure.

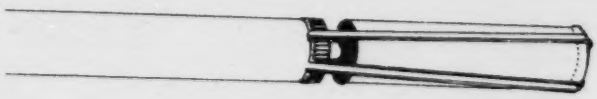
You will need:

bicycle pump
rubber band
metre rule

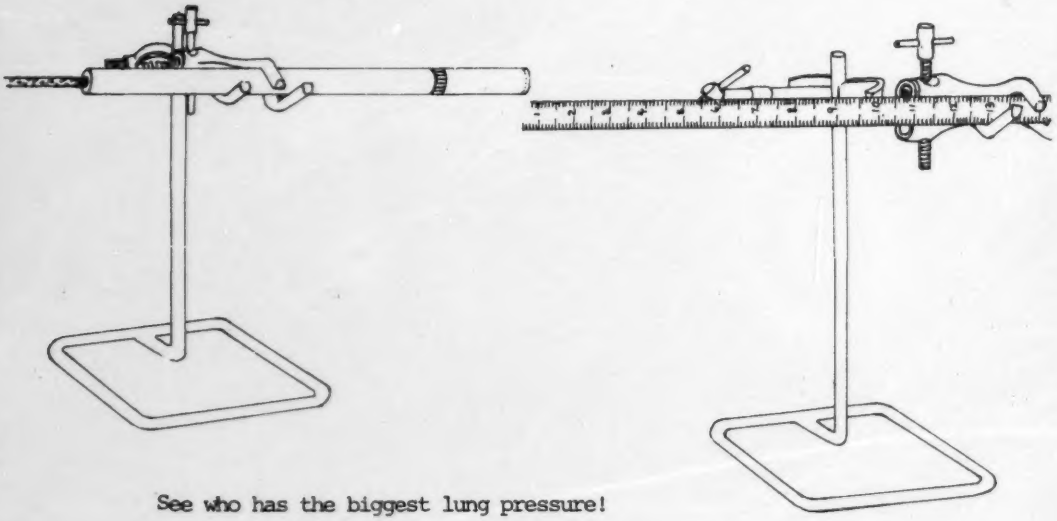
To make it easier to use, cut the end off the pump connection which normally screws into the bicycle tyre.



Fix a rubber band around the top of the pump as shown in the diagram. The rubber band should pass over the top of the pump and be clamped underneath the screw nut in the main part of the pump.



Make a scale (your ruler would be fine) so that pupils can see how far up the scale they can push the plunger. The ruler and pump should be clamped on your stand.



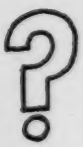
See who has the biggest lung pressure!

Exercise 15:

1. I pushed the gauge plunger to the ——cm mark.
2. The greatest air pressure produced by anyone in the class pushed the plunger to the ----------cm mark.

Pupils should spend a lesson revising Part 3 of this Unit.

Answers to 'How much do you know?'



1. Pressure
2. Bigger
3. (b) smaller - because there are fewer particles banging against the wall.
4. They have more energy so they bump more often against the walls.
5. **Pressure gauge.**

PART 4

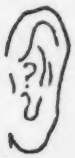
CHEMICAL REACTIONS

The particle model also helps to explain how chemical reactions happen.

The particle model

For the last investigation of the model, choose the same place as you did last time, and put the children into two groups as before. It does not matter if the groups are not exactly equal in numbers. The general idea is that each group is one kind of particle and that the two kinds are going to REACT. You might care to read the following text.

"Lastly, we are going to pretend to be particles taking part in a chemical reaction! You will run around when I say 'GO' and pretend that you are reacting particles. If one of the first group (boys?) bumps into one of the second group (girls?) they must link hands to make a new kind of particle. Remember that you cannot react with one of your own group so if you bump into one of them nothing happens.



Of course the faster you run, the more likely you are to bump into each other. Also you will bump harder if you are running fast! When chemical reactions occur, particles have to have enough energy to bump and stick together. If you do not bump, you cannot form a new COMPOUND. Try to make new particles now.
Go! Run and bump!

Are you all joined up? Perhaps there are some boys or girls left over. This happens in chemical reactions too! If there is too much of one kind of particle, some will be left without reacting. You may have noticed this in your iron sulphide experiment in the last unit. Sit down again now and return to your study guide."

PAGE 37: EXPERIMENT 22: To make and break a Compound

You will need:

water
iodine crystals
iron filings
magnets (one per pair of pupils)

Pupils will need to be very careful when preparing this compound. Please issue each pair with some iodine crystals. The study guide recommends 3 or 4 crystals - these should be large ones. If the crystals are small, give them a few more. Do not give more than half a [illegible] of iodine.

Also issue 1 small spatula iron filings. They can place this in their evaporating dish to keep until needed.

Comments on the Flow Chart:

1. Grinding up the iodine speeds up the experiment.
2. Stirring is important.
3. The red-brown colour will take between five and ten minutes to appear. Do not allow pupils to proceed too quickly. If they are waiting, they can read the chart right through so that they know what is expected of them. They must pour carefully so that no iron filings are carried over to the evaporating dish.
4. Once again, no iron filings should be carried over.

5 & 6. This is the trickiest stage. Pupils should keep the surface of the tin wet by keeping it quite flat at all times. Near the end, they will see dry patches forming. They should remove the dish from the heat when it is almost dry. If necessary, they can heat briefly to drive off the last little bit of water.

7. Before scraping up the compound, the dish should be QUITE COOL. The compound should not be attracted to the magnet.

8. It is essential that they go outside for this stage Iodine fumes are dangerous to the lungs.

9. The iron that remains will be rusty. However, it should be very magnetic.

Cleaning: Pupils should clean out the rusty iron with a little sand and water. The tins must be dried thoroughly after cleaning to prevent rust.

Exercise 16

1. What did you observe in stage 7?
2. What did you observe in stage 8?
3. What did you observe in stage 9?
4. What did this tell you?
5. Write a chemical equation to explain what you were doing in stages 1 - 6.
6. Write a chemical equation to explain what you did in stage 8.

Answers to Exercise 16 (for marking)

1.)
2.)
3.) Pupils observations and deduction
4.)

5. Atoms of iron + atoms of iodine $\xrightarrow{\text{gentle heat}}$ molecules of iron iodide

6. Molecules of iron iodide $\xrightarrow{\text{strong heat}}$ atoms of iron + atoms of iodine

PAGE 40: FINAL SUMMARY AND REVISION

Please make sure that pupils fully understand this Unit. It is very important that they understand the particle concept and its use in explaining temperature, diffusion, pressure, expansion and chemical reactions
They can refer back to the Aims of the Unit and should now be able to understand them. If there is any area of difficulty, please revise that section again.

If you have any comments on this Unit, please write and let us know what they are. We look forward to hearing from you.

THE Zim-Sci TEAM